SAMPLING OF RESERVOIR FISH POPULATIONS WITH ROTENONE IN LITTORAL AREAS

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Abstract: A method of sampling fish populations in the littoral area of reservoirs was developed to estimate the number and standing stock of young-of-the-year (YOY) and adult fishes in West Point Reservoir, Alabama-Georgia. A surface area of 0.01 ha was surrounded with a net (30.5 m x 2.7 m) and the fish were poisoned with rotenone. The sample sites were chosen randomly by using a grid system. The average monthly standing stock (kg/ha) from April to September 1977 ranged from 74.2 in September to 126.1 in June. The weekly samples yielded data that enabled us to estimate the reproductive success and time of spawning for many species. We determined a weekly mortality rate of YOY largemouth bass (*Micropterus salmoides*) and could assess the availability of prey species. By using this method we sampled a wider variety of habitats and collected more species (34) than were taken in large rotenone samples from coves (29) or by electrofishing (28), and provided a reasonable estimate of standing stock in shallow littoral areas. The technique required only 2 people and little specialized equipment.

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A quantitative method was developed to estimate the standing stock of young-of-the-year (YOY) largemouth bass and prey fishes in littoral areas. Information on the growth and mortality of YOY largemouth bass and the sizes of prey fishes available was needed for a continuing study of largemouth bass in West Point Reservoir. Standardized seine hauls were a seine 15 m long were not quantitative because fish escaped under the seine in deep water. Electrofishing was not effective for small fry and fingerlings. A method was required that involved quickly surrounding an area and poisoning the fish with rotenone. The Wegener ring procedure (Wegener et al. 1973) was not effective in deep water. Large cove rotenone collections required too much time and manpower to sample weekly. Estimates of numbers and biomass of juvenile fishes other than bass were required to determine annual reproductive success and prey availability in littoral areas.

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MATERIALS AND METHODS

West Point Reservoir, A U.S. Army Corps of Engineers impoundment of the Chattahoochee River, extends from 5.1 km north of West Point, GA (near the Alabama state line), to Franklin, GA. It lies just above the fall line in the Piedmont physiographic region. It was impounded in October 1974 and filled to full power pool by May 1975. The lake level is maintained at 194 m above mean sea level, except for a 3-m drawdown in the winter for flood control. At the summer pool elevation, the surface area is 10,482 ha, the volume 745.7 million m^3, the shoreline length 845 km, and the average depth 7.1 m. Fish populations in the West Point Reservoir area were surveyed both before impoundment (Shelton and Davies 1977) and after impoundment (Timmons et al. 1977).

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Fishes in the littoral area of West Point Reservoir were collected by surrounding a 0.01-ha area with a net (30.5 m x 2.7 m, with 0.5-cm mesh) equipped with a float and lead line, and applying the fish toxicant rotenone to the area surrounded. One end of the net was anchored on shore and a square was formed by feeding the net off the bow of the boat (Fig. 1). The lead line was immediately examined to be certain it was on the bottom. Enough emulsifiable rotenone (5%) was applied to provide a 1-ppm concentration within the sample area. The material was poured through a weighted hose, or distributed at the surface in shallow water. Fish were collected as they surfaced. Then the net was pulled directly onto the shore and fish in the net were removed. Small fish were preserved in 10% formalin and larger fish wre held on ice in plastic bags. Fish were measured to the nearest millimeter (total length) and weighed to the nearest gram.

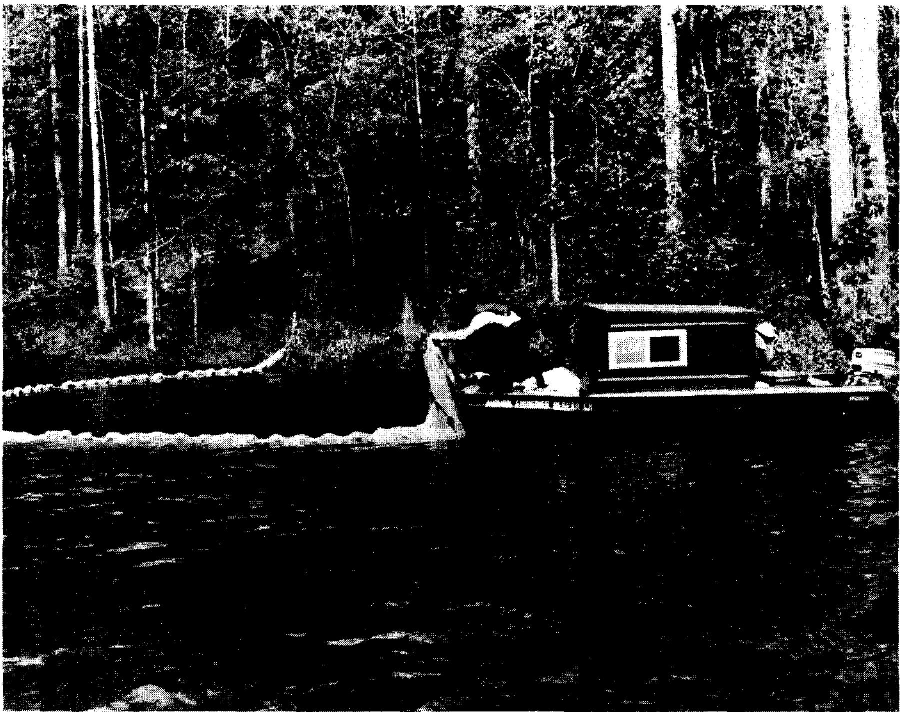

Fig. 1. Setting block off net from boat.

Sampling sites were chosen randomly. The lake was divided into 3 approximately equal areas (Fig. 2): the (I) lower, (II) middle, and (III) upper reservoir. These areas were further divided into a grid system with 0.65-km^2 sections. Each section was assigned a number (from 1 to 500). Open-water sections were eliminated and 1 section within each large area was chosen by using a table of random numbers. A coin was tossed to decide whether the sample would come from the north or south half (or east or west half) of the square. The nearshore region remaining was usually of similar habitat and the 0.01-ha area was selected to be representative of that habitat. Usually 6 samples per day, 2 from each of the 3 large areas, were made each week. Sampling began in April and continued through September 1977.

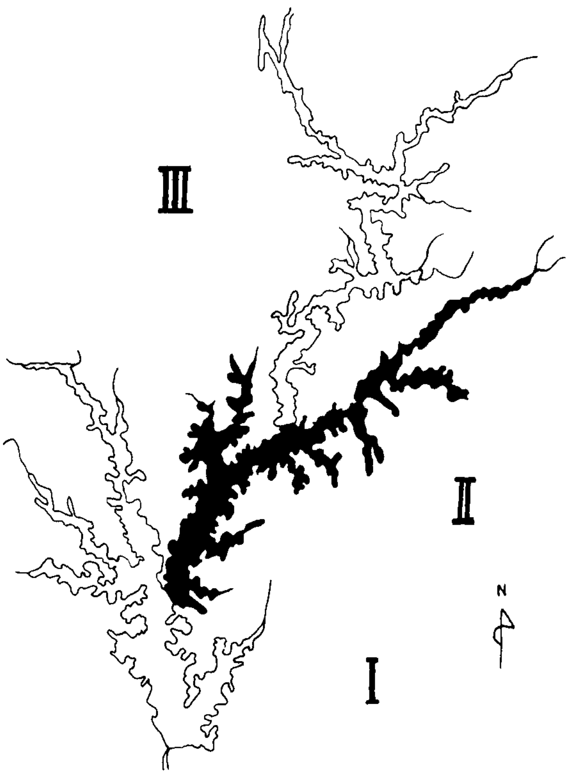

Fig. 2. West Point Reservoir, Alabama-Georgia, showing the 3 sampling regions. (Region II is shaded, regions I and III are not.)

For comparison, we collected fish by 2 other methods, electrofishing and large cove rotenone samples. Nearshore electrofishing samples were made with a boat-mounted 110-volt AC generator and a pulsator unit which provided variable DC voltage. Three 45-min electrofishing samples were taken within each major area. One control location and 2 randomly chosen locations were sampled from each area (I, II, and III) per trip, and 4 trips were made each month.

Fish in large 0.5- to 1-ha coves were collected using rotenone. The general methods of sampling described by Chance (1957) and Hall (1974) were followed. The entrance to the cove was blocked with a 0.9-cm-mesh net. The volume of each cove was calculated on the basis of a plane-table map of the outline and mean depth readings. Emulsified rotenone (5%) was uniformly dispersed within the cove. Potassium permanganate was used to control rotenone drift from the cove. Distressed fish were collected until no more surfaced. The fish were sorted, measured, and weighed. The following morning fish were again picked up and measured. Two control coves were sampled in April and in late summer (July-August); 2 other coves were also sampled in the late summer period.

RESULTS AND DISCUSSION

In 122 collections from littoral areas of West Point Reservoir, the estimated number of fish per hectare increased from April to June and decreased thereafter (Table 1). The

Table 1. Estimated monthly mean number of fish per hectare based on rotenone samples from littoral 0.01-ha areas in West Point Reservoir in 1977 (yount of the year in parentheses).

Species	*April*	*May*	*June*	*July*	*August*	*September*
Amia calva	4	3	5	---	---	---
Dorosoma sp. (larvae)	---	30 (30)	19 (19)	---	---	---
D. cepedianum	1752	1176 (87)	2176 (791)	1208 (329)	1233 (175)	667
D. petenense	*4*	---	*330 (225)*	*600 (250)*	*425 (375)*	*267*
Esox americanus	---	17 (17)	5 (5)	---	---	---
E. niger	3 (3)	13 (7)	5 (5)	4	---	---
Cyprinus carpio	7	10 (7)	10 (10)	4	---	---
Notemigonus crysoleucas	239 (130)	100 (10)	132 (97)	50 (50)	33 (8)	---
Notropis atrapiculus	---	3	---	---	---	---
N. callitaenia	---	3	---	---	---	---
N. longirostris	---	6	5 (5)	---	---	17 (17)
N. lutrensis	3	10	---	4	8 (8)	17 (17)
N. texanus	---	23	---	---	---	---
N. venustus	28	3	11	---	---	---
Catostomid larvae	37 (37)	117 (117)	---	---	---	---
Erimyzon oblongus	---	---	5	---	---	17
Minytrema melanops	---	---	---	4	8	---
Ictalurus catus	---	---	---	8 (8)	---	---
I. melas	---	7 (3)	---	---	---	---
I. natalis	---	7 (7)	11 (11)	17 (17)	---	---
I. nebulosus	15	23 (3)	6131 (6097)	33 (29)	33	17
I. punctatus	---	3 (3)	---	58 (58)	---	---
Gambusia affinis	37	28	168	12	42	---
Labidesthes sicculus	51	78	853 (633)	571 (176)	1458 (1208)	633 (483)
Lepomis sp. (larvae)	---	102 (102)	2558 (2558)	33 (33)	---	---
L. auritus	203	1060	249 (111)	733 (433)	442 (200)	217 (83)
L. cyanellus	132	126	243 (135)	562 (437)	108 (100)	217 (133)
L. gulosus	14	20	14	204 (179)	33 (33)	17 (17)
L. macrochirus	1728	1570	900 (236)	3433 (3120)	1858 (1841)	2183 (2083)
L. marginatus	---	20	10	8 (8)	(17)	---
L. microlophus	41	156	85	54	58 (25)	---
L. punctatus	22	9	5	---	---	---
Micropterus punctulatus	---	---	5 (5)	---	8 (8)	17
M. salmoides	125	448 (397)	704 (611)	633 (596)	217 (183)	67 (33)
Pomoxis nigromaculatus	35	367 (310)	137 (79)	46 (33)	67 (25)	---
Etheostoma fusiforme	---	20 (10)	---	208 (208)	8 (8)	---
Perca flavescens	59 (52)	9 (9)	8 (7)	46 (37)	192 (167)	83 (83)
Young of the year	234	1142	11,640	6001	4381	2949
Yearling and adult	4305	4426	3033	2532	1867	1487
Combined	4539	5568	14,673	8533	6248	4436

number of yearling and adult fish collected per month was about the same in April and May and decreased from June to September, whereas the number of YOY per month reached a peak in June and then declined. Young of the year were collected for 28 of the 34 species taken in the 0.01-ha samples. Young of the year were first collected in April, when the catches included (*Esox niger, Notemigonus crysoleucas*, catostomid larvae, and *Perca flavescens*. Young *N. crysoleucas* reached their greatest density in April. The young of *E. americanus, E. niger*, catostomid larvae, and *Pomoxis nigromaculatus* were most abundant in May. The greatest density of all YOY was in June, when the catches yielded estimates (no./ha) of 791 *Dorosoma cepedianum*, 6097 *Ictalurus nebulosus*, 2558 sunfish larvae (*Lepomis* spp.) and 611 *M. salmoides*. Most of these were postlarvae or juveniles, many or most larvae were probably overlooked because of their small size. The highest numbers of *Ictalurus catus, I. natalis, I. punctatus, Lepomis auritus, L. cyanellus, L. gulosus, L. macrochirus*, and *Etheostoma fusiforme* were collected in July, and most YOY *Dorosoma petenense, Labidesthes sicculus, Lepomis marginatus, L. microlophuys,* *Micropterus punctatus*, and *Perca flavescens* in August. No YOY of *Amia calva*, certain *Notropis* spp., and *Lepomis punctatus* were collected. *Gambusia affinis* YOY were not separated from adults.

The time of peak catches of YOY were not necessarily directly related to the time of spawning, but instead represented the time when the small fish were most vulnerable to sampling. *P. flavescens* is one of the earliest spawners in West Point Reservoir—usually it spawns in early April—but it was collected in greatest numbers in August. Schooling YOY fishes are sometimes difficult to collect in the 0.01 ha samples until the schools break up because fish in compact schools are more likely to be missed than are well dispersed populations. For example, fall sampling showed that A. *calva* spawned in 1977, but no YOY were collected in the 0.01-ha rotenone samples. Adult *Amia* guard their schooling young. The high density estimates for I. *nebulosus* in June was the result of the collection of schools, each with hundreds of young.

The estimated average standing stock of fishes from the littoral areas of West Point Reservoir reached a low of 74.2 kg/ha in September but was as high as 126.1 kg/ha in June (Table 2). The littoral area sampled included only the area between the shoreline and a point 10.2 m from shore—that is, the length of the netted area. Four species accounted for the greatest biomass (average monthly range in parentheses): *D. cepedianum* (40.6-87.8 kg/ha), L. *macrochirus* (5.3-19.3 kg/ha), *M. salmoides* (4.3-11.2 kg/ha), and *L. auritus* (2.0-7.3 kg/ha). Some fishes were part of the littoral zone standing stock during only part of the spring. For example *A. calva* (4.8-9.5 kg/ha) were common in the littoral area during only the first three months. *Notemigonus crysoleucas* were common in April and May (2.6 and 1.2 kg/ha respectively). There was no significant difference ($P > 0.05$) among the total standing stocks of fishes from the littoral zones of the 3 areas of the reservoir (Table 3), as determined by an analysis of variance of the mean monthly estimated standing stocks.

There were no significant differences ($P > 0.05$) between the littoral zones of the 3 areas of the reservoir for largemouth bass either as the number of largemouth bass/ha, number of YOY/ha, biomass, or biomass of YOY. When these data were analyzed by month, the number of YOY largemouth bass was greatest in June and decreased thereafter (Table 4). The monthly average biomass of YOY largemouth bass was never greater than 1.7 kg/ha (Table 5). The average estimated biomass of all largemouth bass ranged from 4.3 to 11.2 kg/ha in different months.

Most of the YOY largemouth bass were collected after dispersal of the schools. Only 1 school was collected in the 0.01-ha rotenone samples; it was in the first collection of YOY bass and was taken in the first week of May. During the next 20 weeks, YOY bass were collected each week except for 1 week in August. The density reached a peak in mid-June and declined thereafter. The decline in abundance was caused by natural mortality and seasonal changes in distribution. Hall and Werner (1977) reported that largemouth bass were in shallow water during the spring and then moved into deeper water by midsummer. Seasonal movements were related to temperature but "the finer resolution of microhabitat utilization" was related to seasonally changing food levels and vegetation development. Allan and Romero (1975) observed that some largemouth bass fingerlings in Lake Mead moved to depths of 7.6 to 18.3 m during late May through July.

Fish were sampled by 3 methods between 1 April and 30 September in West Point Reservoir: 0.01-ha rotenone collections, 0.5- to 1.0-ha cove rotenone collections, and electrofishing. The sample included 122 0.01-ha samples (Fig. 3). Two April and 4 late-summer cove rotenone samples were made. These samples covered a combined surface area of 3.22 ha compared to 1.22 ha samples in 122 of the 0.01 rotenone collections. Fifty-seven electrofishing samples, each of 45 min duration were made.

More species of fishes were represented in the 0.01-ha samples (34) than from the cove rotenone collections (29) or electrofishing collections (28). Forty species were collected by all methods combined (Table 6). The 0.01-ha samples included many small

Table 2. Estimated standing stock (kg/ha) of various species of fish from the littoral rotenone samples (0.01 ha) in West Point Reservoir in 1977.

Species	*April*	*May*	*June*	*July*	*August*	*September*
Amia calva	9.46	4.84	8.44	---	---	---
Dorosoma cepedianum	61.45	40.55	87.85	46.91	59.91	49.55
D. petenense	0.03	---	0.21	1.97	1.98	1.93
Esox americanus	---	t	---	---	---	---
E. niger	t	0.58	--	0.37	---	---
Cyprinus carpio	4.44	2.36	0.03	13.81	---	---
Notemigonus crysoleucas	2.56	1.21	0.01	0.02	1.08	---
Notropis atrapiculus	---	t	---	---	---	---
N. callitaenia	---	t	---	---	---	---
N. longirostris	---	0.03	t	---	---	0.01
N. lutrensis	t	0.02	---	0.02	t	0.02
N. texanus	---	0.06	---	---	---	---
N. venustus	0.05	t	0.02	---	---	---
Erimyzon oblongus	---	---	0.95	---	---	4.41
Minytrema melanops	---	---	---	1.65	2.69	---
Ictalurus catus	---	---	---	t	---	---
I. melas	---	0.29	---	---	---	---
I. natalis	---	t	t	0.01	---	---
I. nebulosus	1.38	1.92	3.21	0.47	3.33	1.22
I. punctatus	---	t	---	0.17	---	---
Gambusia affinis	0.03	t	0.12	0.02	0.02	---
Labidesthes sicculus	0.09	0.33	0.27	0.31	1.34	0.80
Lepomis auritus	2.03	6.55	4.57	7.30	5.44	2.91
L. cyanellus	1.49	2.02	2.03	2.72	0.35	1.50
L. gulosus	0.17	0.57	0.18	0.47	0.08	---
L. macrochirus	13.90	19.30	7.12	9.42	8.86	5.26
L. marginatus	---	0.06	0.17	0.07	0.03	---
L. microlophus	0.78	4.95	3.41	2.63	1.66	---
L. punctatus	0.41	0.12	0.09	---	---	---
Micropterus punctatus	---	---	t	---	0.03	0.65
M. salmoides	11.24	4.98	6.25	4.31	8.71	5.41
Pomoxis nigromaculatus	1.30	1.55	1.17	0.46	1.68	---
Etheostoma fusiforme	---	0.02	---	0.04	t	---
Perca flavescens	0.25	t	0.01	0.90	2.25	0.54
TOTALS	111.06	92.32	126.11	94.05	102.13	74.21

t = less than 0.01

Table 3. Total average standing stock (kg/ha) of fishes from littoral rotenone samples (0.01 ha) from each of the three areas of West Point Reservoir in 1977. No significant difference within month and between areas ($P > 0.05$).

Area	*April*	*May*	*June*	*July*	*August*	*September*
Lower (I)	96.28	29.30	158.17	101.69	113.39	29.34
Middle (II)	121.06	51.10	57.51	70.27	45.37	120.48
Upper (III)	115.83	196.57	162.66	110.20	147.62	72.80
Average	111.06	92.32	126.11	94.05	102.13	74.21

Table 4. Abundance (no./ha) of largemouth bass from littoral rotenone samples (0.01 ha) in the 3 major areas of West Point Reservoir in 1977 (young of the year in parentheses). No significant differences within month and between areas (P > 0.05).

Region of Reservoir	*Month*					
	April	*May*	*June*	*July*	*August*	*September*
Lower	177	264 (182)	584 (468)	350 (288)	100 (77)	50 (0)
Middle (II)	88	1000 (970)	599 (477)	738 (712)	125 (100)	100 (50)
Upper (III)	110	80 (40)	930 (887)	812 (788)	425 (375)	50 (50)
Weight Mean Number	125	448 (397)	704 (611)	633 (596)	217 (183)	67 (33)

Table 5. Biomass (kg/ha) of largemouth bass from littoral rotenone sample (0.01 ha) in the 3 major areas of West Point Reservoir in 1977 (young of the year in parentheses). No significant difference within month and between areas (P > 0.05).

Region of Reservoir	*Month*					
	April	*May*	*June*	*July*	*August*	*September*
Lower (I)	7.49	3.39 (0.09)	1.82 (0.44)	5.63 (0.77)	14.34 (0.26)	8.96 (0)
Middle (II)	5.52	0.81 (0.03)	1.47 (0.45)	2.97 (1.37)	1.95 (0.37)	7.07 (0.27)
Upper (III)	20.70	10.75 (0.15)	15.46 (1.04)	4.33 (2.97)	9.85 (2.20)	0.21 (0.21)
Average	11.24	4.98 (0.09)	6.25 (0.64)	4.31 (1.70)	8.71 (0.94)	5.41 (0.16)

fishes (*Notropis* spp. and *Etheostoma fusiforme*) that were not collected by the other methods. Small fishes were not effectively sampled by electrofishing. Even though the littoral area of large coves sampled with rotenone was thoroughly searched to recover all fish, more species of the smaller fishes were found in 0.01-ha collections. One species, I. *catus*, collected in the 0.01-ha samples was never taken by annual electrofishing (250 samples) or cove rotenone collections (14 coves) since sampling began in 1975. A greater variety of habitats were sampled in the 0.01-ha collections than in the large cove collections because only large coves of suitable size and shape were sampled.

The standing stocks in large coves were much greater than the samples near the shore, even when compared on the basis of area. The estimated average standing stock in April as determined from 0.01-ha samples was 111.1 kg/ha. Two large coves (0.73 ha and 0.57 ha) sampled in April yielded estimates of 249.3 kg/ha and 190.2 kg/ha respectively. The average standing stocks in July and August, as determined from 0.01-ha samples, were 94.0 kg/ha and 102.1 kg/ha respectively. Two large coves (0.50 ha and 0.53 ha) sampled in July yielded 167.0 and 283.6 kg/ha, and 2 large coves (0.55 ha and 0.36 ha) sampled in August yielded 252.8 and 2273.6 kg/ha.

The estimated numbers of YOY bass per ha based on 0.01-ha samples and on large cove samples were similar. Fig. 4 shows the average number of YOY bass collected each week for 20 weeks. During the 13th and 14th weeks the YOY bass were collected from the

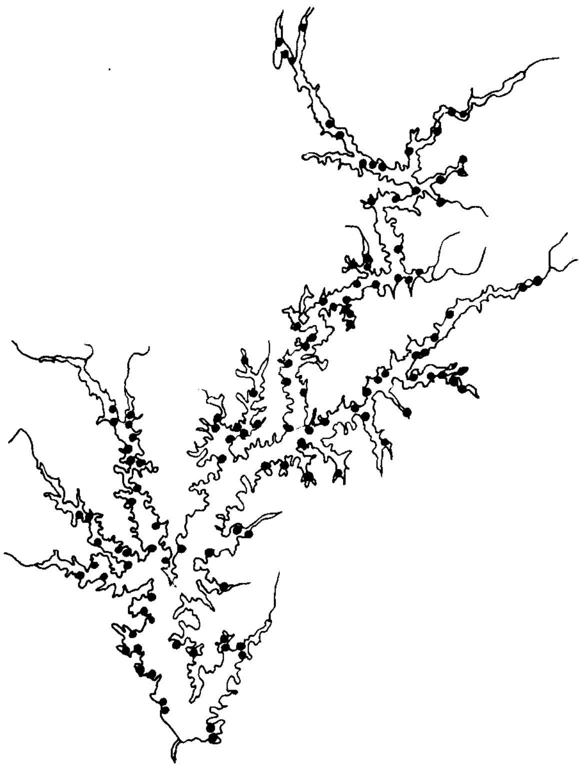

Fig. 3. West Point Reservoir, Alabama-Georgia, showing the sites at which 0.01-ha samples were taken.

large cove surveys and the data for all of the other weeks are from the marginal samples. The values for the 13th and 14th weeks agree with the other samples, suggesting that the decline in numbers after mid-June is more an indication of mortality than of a change in distribution. The weekly estimates of abundance from the 0.01-ha cove samples allow the convenient estimation of the instantaneous mortality rate Z (Fig. 5). The regression of the log of numbers of bass per hectare on time gave the equation $Y = 2.9612 - 0.0948\ x$ ($r = 0.79$). Survival (antilog of the slope) was 0.80; and Z (ln S) was 0.218.

The 0.01-ha samples were useful in determining the weekly mortality of largemouth bass during the first weeks after hatching. They provided quantitative estimates of the number of YOY bass and prey fishes that could be consumed by them. Numbers of YOY bass from 0.01-ha samples were similar to numbers from large cove rotenone samples. Considering that some collections were in very shallow water, the estimated ranges of standing stock in the littoral area of West Point Reservoir are probably close approximations.

Since the 0.01-ha samples represented a wide range of habitat types in the littoral regions of the reservoir, more species were collected than were taken in rotenone samples from large coves or by electrofishing. For most species, YOY were collected in the small 0.01-ha samples and information on the reproductive success was gathered.

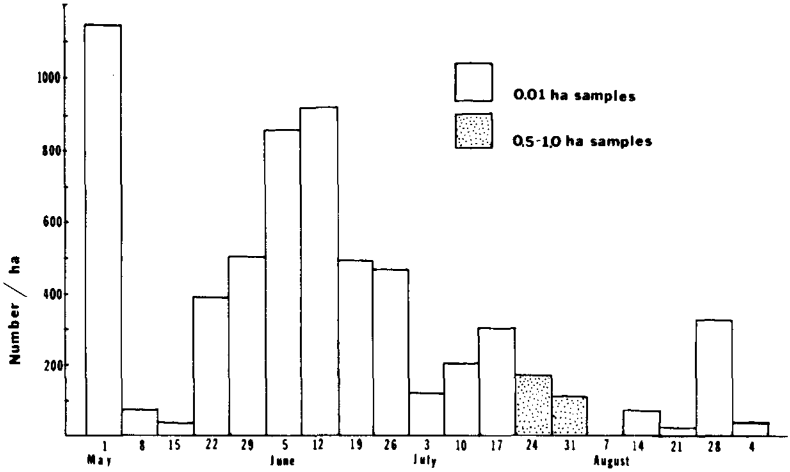

Fig. 4. Number of young-of-the-year largemouth bass per hectare in littoral areas of West Point Reservoir, May - September 1977.

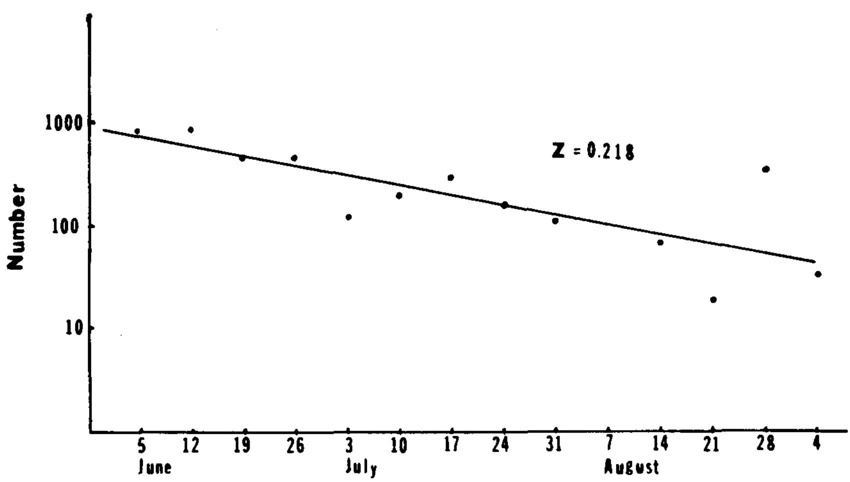

Fig. 5. Mortality of young-of-the-year largemouth bass from littoral areas of West Point Reservoir, June - September 1977.

Table 6 Species collected by three methods during April through September, 1977.

Species	*Rotenone 0.01 ha (122 collections)*	*Rotenone 0.5-1.0 ha (6 collections)*	*Electrofishing 45 min/ samplea* (57 collec*tions*)
Lepisosteus osseus	---	---	X
Amia calva	X	X	X
Dorosoma cepedianum	X	X	X
D. petenense	X	X	X
Esox americanus	X	---	---
Esox niger	X	X	---
Cyprinus carpio	X	X	X
Carassius auratus	---	---	X
Notemigonus crysoleucas	X	X	X
Notropis atrapiculus	X	---	---
N. callitaenia	X	---	---
N. longirostris	X	---	---
N. lutrensis	X	---	X
N. texanus	X	X	---
N. venustus	X	---	---
Erimyzon oblongus	X	X	X
Minytrema melanops	X	X	X
Moxostoma sp. cf. *M. poecilurum*	---	X	X
Moxostoma lachneri	---	X	---
Ictalurus catus	X	---	---
I. brunneus	---	X	X
I. melas	X	---	---
I. natalis	X	X	X
I. nebulosus	X	X	X
I. punctatus	X	X	X
Gambusia affinis	X	X	---
Labidesthes sicculus	X	X	X
Centrarchus macropterus	---	X	X
Lepomis auritus	X	X	X
L. cyanellus	X	X	X
L. gulosus	X	X	X
L. macrochirus	X	X	X
L. marginatus	X	X	X
L. microlophus	X	X	X
L. punctatus	X	X	X
Micropterus punctulatus	X	X	X
M. salmoides	X	X	X
Pomoxis nigromaculatus	X	X	X
Etheostoma fusiforme	X	---	---
Perca flavescens	X	X	X
Total species	34	29	28
Total by all methods	40		

Six of the randomly chosen 0.01-ha rotenone collections were made on the 10,500-ha reservoir by 2 persons in 1 day. Probably as many as 10 or 12 samples could have been made in 1 day but much of the time was spent traveling by boat to the randomly chosen areas. Since a boat, motor, and 30.5-m net are usually available, this type of sampling could be added to an existing program involving reproductive success of fishes, with little additional cost to fishery agencies. A combination of 0.01-ha samples and larval meter net tows could provide useful additional information.

LITERATURE CITED

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